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THE

MARINE BIOLOGICAL STATION AT PORT ERIN

(Isle of Man),

BEING THE

TWENTY-THIRD ANNUAL REPORT

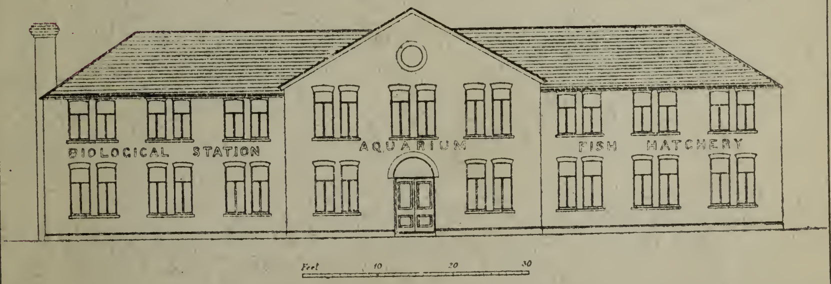
OF THE

LIVERPOOL MARINE BIOLOGY COMMITTEE.

BY

W. A. HERDMAN, D.Sc., F.R.S.,
Hon. D.Sc. (Harvard);
EX-PRESIDENT OF THE LINNEAN SOCIETY OF LONDON AND GENERAL SECRETARY OF THE BRITISH ASSOCIATION;
DERBY PROFESSOR OF NATURAL HISTORY IN THE UNIVERSITY OF LIVERPOOL;
CHAIRMAN OF THE LIVERPOOL MARINE BIOLOGY COMMITTEE,
AND DIRECTOR OF THE PORT ERIN STATION.

[Read, in part, before the Liverpool Biological Society, November 12th, 1909.]



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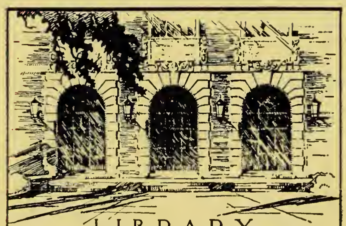

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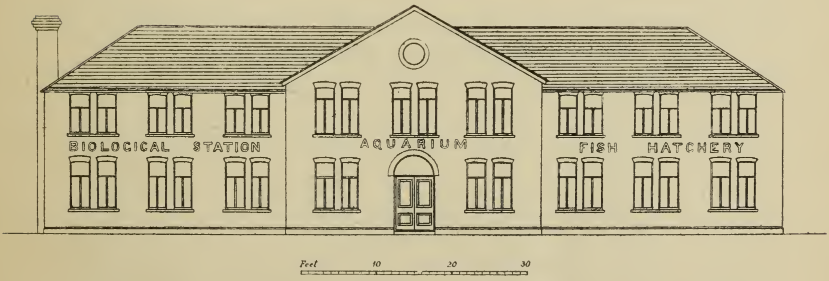

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Liverpool Marine Biology Committee.

Executive.

Chairman and Honorary Director of the Laboratory:

Professor W. A. Herdman, D.Sc., F.R.S.,
University, Liverpool.

Honorary Treasurer:

Mr. Edwin Thompson, 1, Croxteth Grove, Liverpool.

Committee.

His Excellency Lord Raglan, Isle of Man.
Sir John Brunner, Bart., M.P.
Prof. R. J. Harvey Gibson, F.L.S., Liverpool.
Mr. W. J. Halls, 35, Lord Street, Liverpool.
Mr. P. M. C. Kermode, F.S.A. Scot., Ramsey, Isle of Man.
Prof. B. Moore, Liverpool.
Sir Charles Petrie, Liverpool.
Mr. A. O. Walker, J.P., F.L.S., formerly of Chester.
Mr. Arnold T. Watson, F.L.S., Sheffield.

Curator of the Biological Station:

Mr. H. C. Chadwick, A.L.S., Port Erin.

Assistant:

Mr. T. N. Cregeen.

Former Members of the Committee:

The late Mr. R. D. Darbishire.
The late Lord Henniker.
The late Mr. George Holt.
The late Mr. A. Leicester.
The late Mr. J. Lomas, F.G.S.
The late Sir James Poole.
The late Mr. Isaac C. Thompson.
The late Dr. Isaac Roberts.
The late Sir Spencer Walpole, K.C.B.
Mr. John Vicars.
Dr. W. E. Hoyle.

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MARINE BIOLOGICAL STATION AT PORT ERIN,
BEING THE
TWENTY-THIRD ANNUAL REPORT
OF THE
LIVERPOOL MARINE BIOLOGY COMMITTEE.

We have again to record a serious loss in the death of Mr. Lomas, an active and much valued member of the Committee, who was killed in a railway accident in the Algerian desert on the way to Biskra, on December 17th, 1908.

Joseph Lomas, F.G.S., came to Liverpool from the Royal College of Science and School of Mines, South Kensington, where he had been a pupil of Huxley, Judd, Howes, Scott, and other famous teachers. He joined University College as a research student in 1885, and his first research in our laboratories was zoological—although it had a geological bearing too—being on the marine polyzoa, and especially those that build up limestone colonies often found fossil in the rocks. In fact, I think it is the case that throughout his original work the borderland between the two sciences, or rather the applications of zoological knowledge to the interpretation of geological appearances, had a special attraction for Lomas; and that, no doubt, accounted for his enthusiastic support of the Biological Society and the Liverpool Marine Biology Committee, and his helpful participation in our submarine explorations. His special function on these expeditions was to collect, examine, and report upon the nature and origin of the various deposits now being formed on the sea bottom, and to compare them with the more ancient ones that have consolidated into the stratified rocks of the globe. Several of his published papers deal with such collections, and a series of the floor deposits of the Irish Sea, formed and classified under his guidance, is to be found not only in our own University Museum of Zoology, but also in the Museum of the Geological Survey at Jermyn Street, London.

Although in the main a geologist, Lomas often took part in our Biological expeditions, and frequently visited the Port Erin Station. He wrote a detailed report on the Polyzoa for the first volume of our "Fauna," and occasionally named series of specimens or wrote short notes for these Annual Reports. He was added to the Committee last November, just before he started on his fatal expedition to the Sahara. Most of his papers have, however, been Geological, and have appropriately dealt with the Triassic rocks of Lancashire and Cheshire, and Lomas had for several years recently been the secretary of a "Trias Committee" of the British Association, which has produced annual reports upon the extraordinary reptilian footprints and other remains found in profusion in certain beds exposed periodically by the quarrying operations at Storeton and elsewhere in the district. Lomas kept a watchful eye upon the progress of all such excavations, and it is due to his care and knowledge, and to his happy knack of interesting others in what he was studying, that many of the finest slabs of Cheirotheroid footprints have been saved from the quarrymen and are now preserved in our museums. Others of his papers and reports have dealt with glacial phenomena and with more recent changes in the configuration of the country (such as "The Coasts of Lancashire and Cheshire: their forms and origin"), while some have been of wider scope, such as his addresses on the primeval rocks of the earth's crust, and upon "Comparative Lithology." But it is impossible now even to enumerate his various contributions to knowledge. All have been good, and though it cannot be claimed that Lomas has made any very great discovery, he has done much useful original work, carefully detailed and honestly set down. His reputation as a scientific man has been steadily growing amongst scientific men outside Liverpool, and for several years he has acted with marked success as the chief secretary of Section C (Geology) of the British Association.

Lomas was fortunate in obtaining grants from scientific funds, on occasions, to aid in his special investigations, and it was on such a journey—to inquire into the desert conditions in the neighbourhood of Biskra, with a view to a comparison with the Triassic rocks upon which Liverpool is built, and towards the expenses of which he had applied for and received a grant from the British Association at Dublin—that his useful life was prematurely cut short last December. As in the case of many another scientific man, his death came directly in the course of his scientific investigations.

For many years Lomas gave special courses of lectures on Geology and Physical Geography in the University. This volunteer teaching work, although sometimes it must have been heavy enough, was a labour of love, and was hardly, I fear, remunerative. His chief reward must have been the consciousness of the good work he was doing, and the gratitude of his students—several of whom have themselves become geologists.

Most of those who have worked with him will, however, agree that Lomas was at his best in "the field" on geological or biological expeditions. He was pre-eminently an open-air student of nature, and he could lead a party over the country all day, and day after day, impressing upon them in the happiest manner both the minutiæ of rocks and fossils and the broad features of stratification and mountain building, or water drainage and the connection between landscape and geological structure. Many of us have recollections that will never fade of such days in Wales, or the Isle of Man, in the Lake Country, on the Yorkshire moors, and even in far South Africa. And beyond the earth-lore and all else that he taught us then and at other times, we shall ever remember the constant good nature and cheerful determination to make the best of everything, the helpful resourcefulness in times of difficulty, and the honest reliability and general sterling, lovable character of the friend we have lost.

I would again point out that, in view of the loss of so many of their old fellow-workers and supporters in the last year or two, the Committee are most anxious to get some younger men as recruits to fill the places thus left vacant, both as actual workers in the field and also as subscribers to the funds. There are now plenty of students—in fact, during the Easter vacation the Biological Station has, for the last few years, been practically full—and there are plenty of young professional researchers; but we have very few left of the earnest amateur naturalists who were our main support in the early days twenty years ago. The place left vacant on the Committee by the death of Mr. Lomas has been filled by the election of Dr. Benjamin Moore, Professor of Bio-Chemistry in the University of Liverpool. Professor Moore has for several years taken a keen interest in the work of the Committee. He has on several occasions carried on research in vacations at the Port Erin Station, and in association with Mr. E. Whitley and Dr. H. E. Roaf has developed a new side to our work, viz., Bio-Chemistry and Comparative Physiology—a side of biological investigation which is most appropriate to a marine laboratory, and one which will probably be actively pursued in the future.

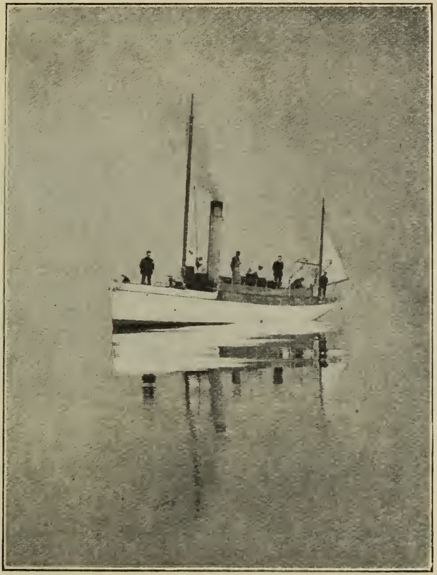

Fig. 1.—S.Y. "Ladybird," on a Plankton cruise at Easter, 1908, from a photo by Edwin Thompson.

The dredging, tow-netting and other investigations at sea, started two years ago with the yacht "Ladybird," have been carried on vigorously during the Easter and Summer vacations of 1909. Nearly 800 samples of plankton have been collected with various nets in the seas around Port Erin and have been sent to Mr. Andrew

Scott for microscopic investigation. During the Easter vacation Mr. W. Riddell, M.A., of Belfast, again gave me most valuable assistance in taking daily Plankton observations from the yacht. Mr. W. J. Dakin at the same time took charge of the corresponding Hydrographic work, and Mr. W. Gunn, from the Liverpool Laboratory, also gave efficient help. Some account of the results of these observations, and of the objects and methods of plankton-work in general, will be found further on in this Report.

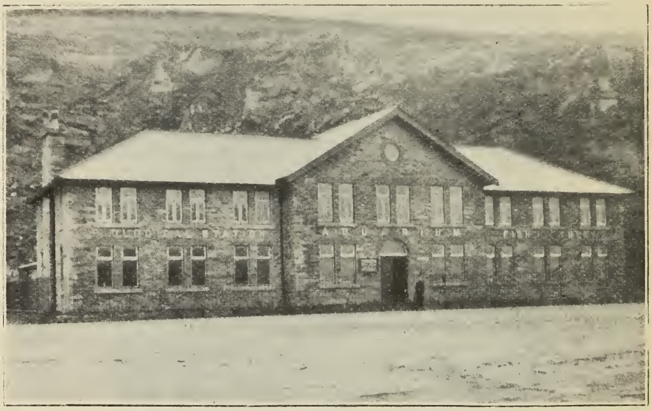

Fig. 2.—The Biological Station and Fish Hatchery at Port Erin, from a photo by Edwin Thompson.

Our Hon. Treasurer, Mr. E. Thompson, at Easter, and Dr. F. Ward in Summer, were engaged in Photomicrographic study of developing fish embryos and other subjects. I am indebted to both these friends for beautiful photographs, from which some of the illustrations in this Report have been prepared.

The fish and lobster hatching, carried on for the Isle of Man Fisheries Board, will be found reported on in detail below. Judged by the number of summer visitors, this has been a poor year in the Isle of Man generally, and as a natural consequence our numbers in the Aquarium record have fallen. We consider that under the circumstances we have not done badly in having between thirteen and fourteen thousand visitors who paid for admission. The institution, it will be remembered, is carried on jointly with the Fisheries Board, the receipts and the expenses being shared equally with that Authority.

As on previous occasions, Mr. Chadwick has supplied a "Curator's Report," which will be found below, and he has also, as usual, supplied me with details for some other parts of this Report.

THE STATION RECORD.

Forty naturalists and students have occupied the work-tables in the Laboratories for varying periods during the year, as follows:—

Dec. 28th to Jan. 9th.	Professor Herdman.—Official.
Feb. 20th to 22nd.	Professor Herdman.—Official.
March 26th to April 27th.	Professor Herdman.—Plankton.
,, ,,	Mr. W. Riddell.—Plankton.
April 1st to July 27th.	Mr. W. J. Dakin.—Sense organs of Mollusca.
April 3rd to 20th.	Dr. H. E. Roaf.—Physiology.
April 8th to 12th.	Mr. E. Thompson.—Photomicrography.
April 10th to 26th.	Mr. W. Gunn.—General.
April 13th to 27th.	Mr. R. D. Laurie.—Educational.
,,	Mr. Billington.—General.
April 13th to 22nd.	Mr. Johnson.—General.
April 14th to 27th.	Dr. Pearson.—Educational.
April 13th to 27th.	Mr. H. G. Jackson.

Miss E. M. Blackwell.
Miss A. B. Dixon.
Miss K. Winston.
Miss M. M. Heap.
Miss E. Matthewman.
Miss E. Bland.
Miss M. Scott.
Miss Prescott.
Miss L. W. Whitehurst.
Miss M. Latarche.
Miss A. Lee.
Miss A. G. Wildman.
Miss F. Uttley.
Miss M. Southerst.
Miss E. Horsman.
Miss A. Lennon.
Miss T. A. Smith.
Miss D. Lawson.

April 20th to 23rd	Mr. R. Williams Ellis.—General.
May 19th to June 10th.	Dr. Ward.—Photography of living Fishes.
July 7th to Aug. 9th.	Mr. F. H. Gravely.—Polychaeta.
July 7th to Aug. 19th.	Mr. S. Garside.—Marine Algae.
July 11th to 23rd.	Mr. Pryce.—General.
July 24th to Aug. 14th.	Miss C. E. Wetherall.—Polychaeta and Tunicata.
July 27th to Sept. 10th.	Dr. H. E. Roaf.—Physiology of Invertebrates.
July 31st to August 14th.	Mr. W. A. Gunn.—General.
Aug. 1st to 12th.	Professor Herdman.—Plankton.
Sept. 4th to 14th.	Mr. T. J. Evans.—General.
Sept. 4th to Oct. 2nd.	Dr. H. Henry.—Haemoflagellates of Fishes.
Sept. 27th to 30th.	Miss Wilkinson.—Crustacea.
Sept. and Oct. (occasional visits)	Mr. C. Okell.—General.
Nov. 29th to Dec. 17th.	Miss B. Watterson.—General.

The "Tables" in the Laboratory were occupied as follows:—

Liverpool University Table :—

Prof. Herdman.
Dr. Roaf.
Dr. Pearson.
Mr. Laurie.
Mr. Dakin.
Mr. Gunn.
Mr. Billington.
Miss B. Watterson.

Liverpool Marine Biology Committee Table :—

Mr. E. Thompson.
Dr. Ward.
Dr. Henry.
Mr. C. Okell.
Mr. R. Williams Ellis.
Mr. Pryce.
Mr. Evans.
Mr. Riddell.

Manchester University Table :—

Mr. Gravely.
Mr. Johnson.
Mr. Garside.
Miss Wilkinson.

Birmingham University Table :—

Miss Wetherall.

The following students of Liverpool University occupied the Junior Laboratory for a fortnight during the Easter vacation, and worked together under the supervision of Professor Herdman, Dr. Pearson and Mr. Laurie:—

Miss Lawson.
Miss Whitehurst.
Miss Smith.
Miss Prescott.
Miss Lennon.
Miss Scott.
Miss Horsman.
Miss Bland.
Miss Southerst.
Miss Matthewman.
Miss Uttley.
Miss Heap.
Miss Wildman.
Miss Winston.
Miss Lee.
Miss Dixon.
Miss Latarche.
Miss Blackwell.
Mr. Jackson.

CURATOR'S REPORT.

Mr. Chadwick reports as follows:—

"The scientific work of the past year has been marked by some increase in the number of workers in our laboratories, and of researches which involved longer periods of time and more extensive use of the facilities afforded by the Station and its equipment. The Easter vacation class-work was again completely successful, and showed the advantage of a number of students working together under competent guidance and within easy reach of abundance of living material. Amongst the twenty-nine students and researchers who occupied tables during the year there were representatives of the Universities of Cambridge, Liverpool, Manchester, Birmingham and Sheffield.

"During the winter much time was devoted to careful revision and remounting of museum specimens. The whole of the collection of Molluscan shells was thus dealt with, and some new specimens were added.

"The study of Marine Plankton has again figured largely in the year's work. Tow-nettings have been taken twice a week, over a prescribed course in the bay, with as much regularity as the weather would permit, and a larger share in the laborious work of estimation and qualitative analysis of the gatherings has been undertaken by the Curator.

"The number of visitors to the Aquarium, compared with the records of the previous two years, shows a considerable falling off. This was clearly due to the fact that the Isle of Man as a whole did not enjoy its usual measure of patronage during the visitors' season. The tanks were as well stocked as in previous years, and there was no indication of waning interest on the part of the 13,500 visitors who paid for admission. The number of copies of the 'Guide to the Aquarium' sold also shows a considerable falling off. We have abundant evidence, however, that this 'Guide' has been regarded by many visitors as a welcome addition to the popular literature of Marine Biology.

"Owing to the continued growth of living organisms in the circulation pipes, to which reference was made in last year's Report, it was found necessary to take down and thoroughly clean the whole system. This was done during the months of November and December, 1908; and at some points, especially the bends, the bore of the pipe was found to be almost completely obstructed by colonies of barnacles, mussels, and other molluscs. Before re-erection the lengths of piping were provided with flanges at their ends, so that it is now possible to remove and clean any length without disturbing the neighbouring ones.

"The tanks have been maintained in excellent condition by the Assistant Curator, and the mortality amongst the fishes and invertebrates has been quite insignificant. The largest conger has now been an inhabitant of the aquarium for nearly 4½ years, and has attained a length of exactly 6 feet.* Another specimen, about 4 feet long, is the 'oldest inhabitant,' having occupied the same tank for over five years.

"The hatching season of 1909 fully justified the anticipation expressed by the Curator in last year's Report. The number of plaice larvæ hatched and liberated, 7,124,500, was nearly double that of the previous year, and brings the total number for the six years during which the hatchery has been in operation to twenty-five and a half millions.

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* This fish died on Friday, December 3rd. Its length was exactly 6 feet; maximum girth, 2 feet; weight, 59½ lbs.

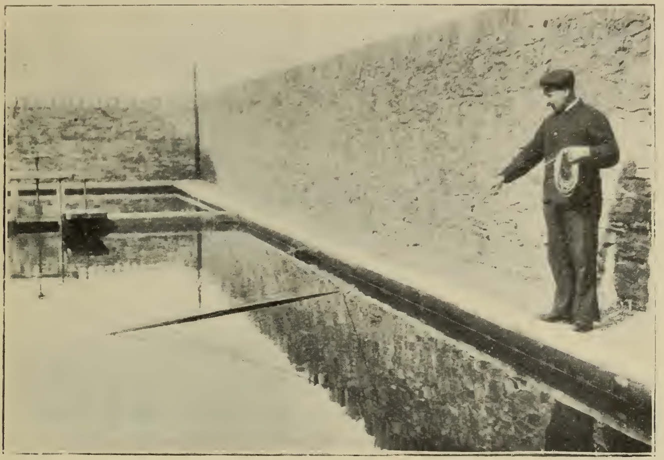

FIG. 3.—Mr. T. Cregeen collecting fish eggs from the surface of the spawning pond, from a photo by Edwin Thompson.

"The numbers of eggs collected and of larvæ set free during the season were as follows:—

Eggs collected.		Date.	Larvæ set free.		Date.
90,500	...	February 22—26	78,000	...	March 22
253,500	...	February 27—March 3	184,500	...	,, 27
218,000	...	March 4 and 5	148,000	...	,, 29
179,000	...	,, 6 and 8	146,000	...	,, 30
196,000	...	,, 9 to 12	126,000	...	,, 31
957,000	...	,, 13 to 17	766,500	...	April 5
737,000	...	,, 18 to 20	609,000	...	,, 8
732,000	...	,, 22 and 23	603,000	...	,, 10
545,000	...	,, 24 to 26	400,000	...	,, 13
391,500	...	,, 27	286,500	...	,, 14
189,000	...	,, 29	147,000	...	,, 15
990,000	...	,, 30—April 3	754,000	...	,, 19

Eggs collected.		Date.	Larvæ set free.		Date.
619,000	...	April 5 and 6	441,000	...	,, 21
331,000	...	,, 7	257,000	...	,, 22
1,063,000	...	,, 8 and 9	849,000	...	,, 24
683,000	...	,, 12 and 13	520,000	...	,, 26
194,000	...	,, 14	142,000	...	,, 27
957,000	...	,, 15—20	667,000	...	May 3
9,325,500			7,124,500		

"A few thousands of additional fertilised eggs were collected on April 28th and May 10th; but the resulting larvæ were retained in the hatchery for scientific observation and experiment.

"The Curator regrets to say that, in spite of continued efforts and experiments on new lines, the problem of artificial lobster rearing remains practically unsolved. The initial difficulty—that of obtaining berried female lobsters with nearly ripe eggs—was greatly felt during the past season, and the total number of larvæ hatched did not reach 1,500. A wooden tank measuring 6 × 6 × 4 feet, with openings screened with wire gauze in the sides and bottom, was fixed in the western spawning pond, and an attempt was made to rear in it a number of lobster larvæ. This, in spite of abundant food material and liberal aeration of the water, proved a failure, none of the larvæ surviving the third stage of development. Mr. W. J. Ashburner, who made the tank, has further provided an apparatus for keeping the water therein in constant motion, and with this further experiments are to be made next summer. There is evidence that berried lobsters will retain their eggs if kept in the pond and provided with suitable hiding places; and the Curator is now accumulating a stock in the hope of ensuring a large number of larvæ next year.

"In response to an invitation by the Isle of Man Fisheries Board, representatives of the various Insular education authorities met in the junior laboratory on April 6th to hear an address from Professor Herdman on "Education," especially in its relations to modern science and modern requirements. The Deemster Callow occupied the chair, the Clerk of the Rolls and other members of the Council of Education were present, and in the course of the lecture Professor Herdman showed how an institution such as the Biological Station might be utilised by the schools of the Island for purposes of training in observation and for giving facilities to teachers in connection with some aspects of higher education."

Mr. Dakin's Report.

"The following is a brief account of some of the research carried out during my stay at Port Erin, which lasted four months, from April 1st until the end of July. My time was spent chiefly on three subjects, two of which are more or less related, and work on these was commenced at the Zoological Station of Naples. During the month of April, whilst Professor Herdman was at Port Erin, I took charge of the hydrographical observations made from his yacht, simultaneously with the plankton catches. There is now a very complete set of hydrographic apparatus at Port Erin, and I was able to fit up a small chemical laboratory with the necessary apparatus for the analysis of sea-water, so far as chlorine and oxygen are concerned. A very complete series of observations was made, which will be published in connection with Professor Herdman's Plankton Studies. After the Easter vacation, quantitative tow-nettings were taken regularly twice a week at a locality out at sea, two to three miles west of the Breakwater, and these were continued until the first week in July. They demonstrated, probably for the first time in the Irish Sea, the length of the period of the vernal diatom maximum, which this year extended to May 24th.

"My other work dealt with the minute histology of the eye of *Pecten*, and a study of the visceral ganglion and the innervation of the osphradium in the Lamellibranchiata. The former research is being published in the Quarterly Journal of Microscopical Science, and a preliminary communication on the latter will be given here. Representatives of twelve genera belonging to nine sub-orders have been examined, and the course of the osphradial nerves has been traced by the method of serial sections. In several recent text-books, statements have been made, based apparently on a short paper of Pelseneer's, that the osphradium is innervated by the cerebral ganglion. Thus in the volume on the Mollusca in Ray Lankester's 'Treatise on Zoology,' we have 'The osphradial ganglion receives nerve fibre *not* from the visceral ganglion, but from the cerebral ganglion by way of the visceral commissure.' A similar statement occurs in Lang's 'Comparative Anatomy.' I find that in all the species examined, the osphradial nerve fibres arise from the branchial nerve, which takes its origin in the visceral ganglion, except in the case of *Pecten maximus*, where, in addition to this, two distinct nerves can be traced directly from the ganglion. No nerve fibres leave the cerebrovisceral connectives for the direct innervation of the osphradium.

"During the examination of some of these lamellibranchs, the remarkable Nemertean *Malacobdella* was discovered in the pallial cavity of *Venus casina*, and also in *Mya truncata* from Piel. The usual host is *Cyprina islandica*, but I am not aware of any previous records of the occurrence of this Nemertean worm in the Port Erin district, or of its occurrence in these two molluscs, though Mr. Johnstone tells me he has found it in *Mya truncata* at Piel. It is probably not restricted to these three species.

"An interesting ciliate Infusorian, *Licnophora auerbachii*, which is also, I believe, a new record for the district, turned up on the tentacles of *Pecten maximus*.

"I should like to thank Professor Herdman, and also Mr. Chadwick, for the space allotted to me in the laboratory, which exceeded, I am afraid, very considerably the normal bounds, and for all the trouble they have taken to facilitate my work in various ways."

Mr. Gravely's Report.

"The stormy weather this summer interfered considerably with work on pelagic larvæ. For it was found that healthy specimens disappeared from the plankton during a storm, and did not return until almost all the sand which was stirred up had settled down again—a process which always took several days to complete. The only larva which I have to record as new to the bay is '*Ophiopluteus compressus*,' of the 'Nordisches Plankton,' a single specimen of which was taken on July 22nd. As this presents a mode of development not hitherto recorded in Ophiuroids, a description of it may be of some interest. The hydrocœl is situated on the left of the alimentary canal, and extends forwards slightly beyond the mouth, which would be perfectly symmetrical if it were not slightly drawn out into a point on the left side. The part of the hydrocœl near the mouth, however, will not eventually surround it, for it already bears at least two pairs of developing tube-feet: and (from the presence and position of similar papillæ on other parts of the larva, and of certain small plates that appear to be developed in connection with the hydrocœl) it is evident that this is already star-shaped; that it is situated entirely on the left side of the pluteus and orientated as in Echinoplutei at this stage; and that the larval mouth will not take part in the formation of the permanent mouth. Moreover, as in *Echinus* again, there appears to be a membrane closing in an amniotic cavity, into which the tube-feet project. The plates of the Ophiuroid to which the larva gives rise have developed to such an extent that the 'terminal' plates of the arms project from the body in the form of a star, but (like the hydrocœl) instead of lying in the horizontal plane of the pluteus, as is usually the case at such an advanced stage of development, they lie in a plane at right angles to this—the plane in which they always make their first appearance in Ophioplutei. The plates of the aboral surface have reached a corresponding stage in their development, and also lie roughly in the plane of their original formation. These 'terminal' and aboral plates do seem to have moved very slightly towards the position assumed by those of other Ophioplutei, but this movement, as shown by the position of the middle of the central (aboral) plate, only amounts to a rotation through about 12° instead of 90°. It is unlikely, in view of the condition of the hydrocœl, that any further *rotation* will occur; but that some migration of plates will take place is shown by the position of the 'terminal' plate corresponding to the forwardly directed arm of the hydrocœl. This plate, as noted above, is still in its original position (i.e., near the stomach of the pluteus), whereas this arm of the hydrocœl extends beyond the mouth. Thus the directness of development found in *Echinus*, where the plates and soft parts arise together in their final relative positions, has not been fully acquired by this Ophiuroid.

"From this account it will be seen that the mode of development of *Ophiopluteus compressus*, whilst retaining traces of that usually found in Ophiuroids, is as a whole much more like that of Echinoids.

"A few specimens of the epauletted *Ophiopluteus* noted in my last year's report were again obtained. They are probably identical with Mortensen's *Ophiopluteus henseni*, a species described from a single specimen from Bermuda in the report of the German plankton expedition. The absence of the skeleton in Mortensen's specimen, however, must make any identification a little uncertain.

"The following Polychaets, all from under stones and Laminarian roots at Poyllvash, are, I believe, new to the L.M.B.C. area:—*Sphaerodorum* sp., *Nematonereis* sp., *Staurocephalus* sp., *Scoloplos* (*Theodisca*) *mamillata* (Clap.)—also found in Port Erin Bay below the Biological Station, *Polydora caeca* (Œrst.), and *Dodecaceria* (?? *concharum*, Œrst.).

"As all these worms were obtained in two short visits, a full investigation of the locality would probably yield many more new forms.

"Amongst the Laminarian roots a small specimen of the locally rare *Phascolosoma vulgare* was found, and a smaller Gephyrean was fairly abundant. The specimens of the latter are maggot-like creatures, 5-8 mm. in length, with an introvert of about 4-6 mm. The lophophore is represented, as in the genus *Petalostoma*, only by a pair of lobes—which, however, vary a great deal in distinctness, and often appear to be entirely absent. Moreover, the Poyllvash species differs from the type (*P. minutum*, Kef.) in having only two instead of four retractors.

"As no investigations of the worm parasites of the district appear to have been made as yet, I should like to record here the great abundance of the curious Gregarine *Ancora* (*Anchorina*, Ming.) *sagittata* in the gut of the common *Capitella* of Port Erin sands, and of the (?) ciliate *Anoplophrya* in the gut of *Cirratulus*."

DR. ROAF'S PHYSIOLOGICAL WORK.

Dr. H. E. Roaf continued his investigations of last year* on the digestive processes in marine invertebrates. The results so far are partly in the form of observations on the nature of the food and the manner of feeding of several species, but more especially of *Echinus esculentus*, and partly experiments directed to determine the presence of acid or alkali in the alimentary canal during digestion. This latter investigation was carried out by using food dyed with chemical indicators, so that on examination after various periods of digestion the degree of the reaction could be determined. These experiments also gave some information as to the reaction of the organs, other than digestive, as the indicators when absorbed were capable of colouring the tissues in general.

A large white anemone (*Actinoloba dianthus*) was fed with pieces of fibrin soaked in methylene blue, with the result that the tentacles, and to a less extent the mouth-disc, became stained in a most striking manner. The blue tint is remarkably persistent, and remained unaltered for seven months, while the anemone was under observation in the tanks. Mr. Chadwick states that the colour has recently become re-distributed, and is now confined to a series of bands running circularly around the body-wall, and especially at the upper end close to the bases of the tentacles.

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* Since published in the Bio-Chemical Journal, Vol. iii., 1908, pp. 462-472.

Whilst collecting large white anemones for this and similar work, Dr. Roaf found a specimen (see fig. 4) which was nearly divided into two distinct anemones. The mouth-discs and circles of tentacles are absolutely separate, but the two bodies join about two-thirds of the way up from the base. This is probably a case of partial fission, such as is known to occur sometimes in this and other anemones. G. H. Parker has described it in the American *Metridium marginatum*, and Dr. J. A. Clubb found the same in a Metridium (Actinoloba) from the Mersey, which completed its longitudinal fission in the tanks under his observation. Dr. Roaf found that when one mouth was fed with neutral-red stained food, the neighbouring tentacles became pink and remained coloured for four weeks, while those around the other mouth remained white. When one disc was stimulated the tentacles of that part contracted, and those of the other only followed more slowly after a slight interval, probably as a result of a secondary stimulation caused by the contracted state

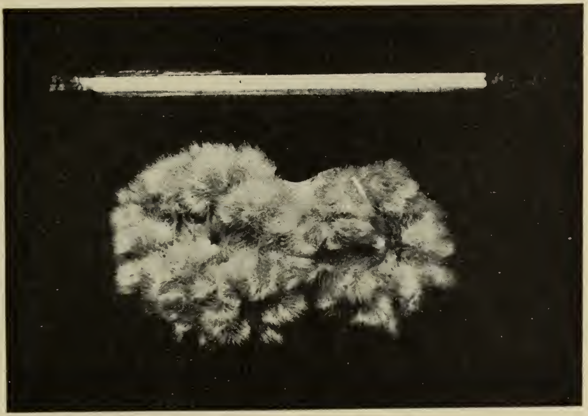

FIG. 4.—Specimen of *Actinoloba dianthus* showing fission.

of the neighbouring body exercising a pull upon the tissues. It is therefore inferred that in this "Siamese-twin" arrangement there is no communication between the digestive cavities and no direct nervous connection.

Dr. Roaf made a number of interesting observations on the manner in which *Echinus*, the Sea-urchin, catches its food and passes it around the body by means of its pedicellariæ, spines and tube feet, and on the movements of the teeth when the desirable particle is approaching the mouth. All of these investigations will be published in fuller detail in a paper to appear shortly.

Dr. Francis Ward's Photomicrographs.

(See Plates II and III, pp. 34 and 35).

"At the invitation of Professor Herdman, I show (Plates II and III) a few photographs of the early life-history of the plaice taken in the Fish Hatchery at Port Erin in May, 1909, and will describe the methods I employed in making these records of the living specimens.

No. 1 shows the Plaice Larva almost hatched, × 25.

"I noticed that during hatching the tail is frequently used as a fixed point; and then by spasmodic contractions of the back muscles the head and shoulders are made to impinge on the edge of the originally small rent in the egg membrane, until the opening is torn large enough to permit the larva to escape.

No. 2 shows the Plaice Larva hatching tail first, × 25.

"In photographing various larvæ hatching, I have observed that certain fish, e.g., the Perch (*Perca fluviatilis*), which have a very small yolk sac, hatch tail first, then the body, and lastly the head, through a small hole; but with Plaice larvæ, as with Salmonoid Alevins, hatching is delayed at the stage shown until the head also breaks through.

No. 3. Plaice Larva hatched 3 minutes, 6·5 mm. in length, × 15.

" In No. 3 the light was moved slightly to one side, so that the illumination was partly by transmitted and partly by reflected light, and the light being no longer directed into the lens, a dark background was obtained. This method is very useful in photographing delicate structures.

" Nos. 4 to 9 (Pl. III) show the changes by which the bi-laterally symmetrical larva becomes an asymmetrical flat fish. All are enlarged about 7 times.

No. 4. Larva just hatched, length 6·5 mm.

No. 5. Larva hatched 7 days, length 7·5 mm.

No. 6. Larva of length 9·5 mm.

No. 7. Larva of length 10 mm.

" This specimen shows a greater relative growth dorso-ventrally than longitudinally, a sign of commencing metamorphosis which is supposed to occur about the 30th day after hatching.

No. 8. Larva of length 11·5 mm.

" This shows the rotation of the cranium through its longitudinal axis, and the consequent carrying over of the left eye.

No. 9. Larva of length 13 mm.

" This shows the metamorphosis progressing, and the next stage examined showed it completed.

" The first five photographs were from ova or larvæ in the hatching boxes; the last four specimens were obtained from the spawning ponds at the Biological Station. All the specimens were photographed while alive, except No. 9. In this case I waited until the heart stopped beating, in order to show that structure satisfactorily.

" As to the apparatus used:—A deal board, four feet long and six inches wide, carried on one side two rails, four inches apart, running the whole length. At one end of the board was screwed a 5 × 4 Planex Reflex camera. I removed the panel carrying the lens, and temporarily fixed on a 10-inch wooden extension for the lower magnifications, and a longer extension made with wire and brown paper for the higher magnifications. These extensions ran along the rails as the camera was racked out. A 2-inch block of wood, also running on the rails, carried a cell in which was the living larva in sea-water. A second block of wood carried an 8-inch condenser. The illumination was obtained from an acetylene bicycle lamp.

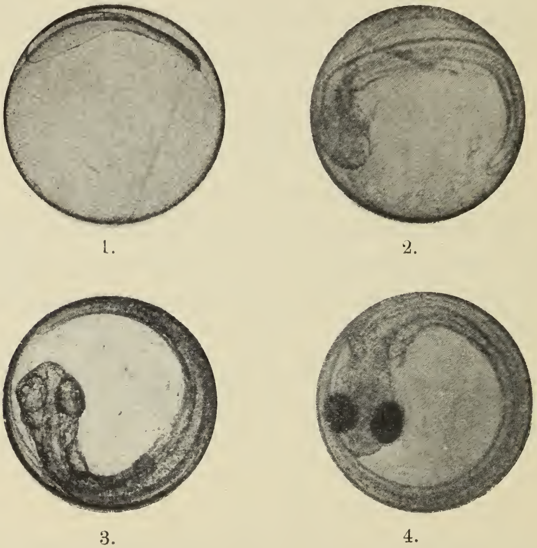
1. 2. 3. 4.

Fig. 5.—Four stages in the early development of the Plaice before hatching. From photomicrographs by Edwin Thompson.

"The lens used for photographs 1, 2 and 3 was a Zeiss micro-planar of 35 mm. focal length; and for photographs 4 to 9 a 3½-inch Beck. The lenses were stopped down from F 11 to F 16, and the exposures varied from 10 to 15 seconds.

"For this kind of work the best lens is one of about 3-inch focal length, the magnification being obtained by having the plate a considerable length from the lens; by this means the whole thickness of the object to be photographed can be brought into focus without having to use a small stop and so sacrifice light.

"These photographs were taken with the cell in a vertical position, and the cell used was just the depth of the object to be photographed, which object was kept in position by the cover glass. This method entails considerable trouble, and there is a danger that the specimen may be compressed.

"Since returning from Port Erin I have constructed a more elaborate apparatus, so as to be able on my next visit to photograph specimens with the cell in a horizontal position, and so avoid all risk of compression.

"I have to thank Mr. Chadwick, and his assistant, Mr. T. Cregeen, for the immense trouble they took in procuring suitable specimens in the successive stages, and Mr. W. J. Dakin for many useful suggestions."

In addition to the above described work by Dr. F. Ward, our Hon. Treas., Mr. Edwin Thompson, has devoted much attention during the year to making Photomicrographs of living Plankton. Fig. 5 shows four of his series illustrating the embryonic development of the plaice. These all represent earlier stages than those figured by Dr, Ward (Pl. II.), which commenced with the hatching of the larvæ. Mr. Thompson has also prepared a number of photomicrographs of typical samples of different kinds of plankton, and a few of these are shown in Pl. I., p. 33.

"OUR FOOD FROM THE SEA."

It is plain, from questions that have been asked from time to time by readers of these Annual Reports and by visitors to the Biological Station, that some of our supporters, both in Liverpool and the Isle of Man, would be glad of further information as to the nature of "Plankton," and as to the method and object of that Plankton investigation to which so much attention has been devoted during recent years. I shall therefore quote here, with a few alterations and additions, some paragraphs from an address on "Our Food from the Waters," given before the British Association, at Winnipeg, this autumn—the argument being that the marketable fish which man obtains from the sea and from fresh-waters are ultimately dependent for existence upon the minute plants and animals found in varying quantity in all waters, and known as "Plankton"; and that in collecting, examining and attempting to estimate the quantities of such organisms, under different conditions, and to account for the marked variations in these quantities, the Biologist is dealing with important economic questions, and at the same time is brought face to face with some of the greatest world problems still unsolved by science.

It is possible to collect samples of the surface Plankton of the sea in any required quantity per day or hour from an ocean liner going at full speed, and such gatherings have now been made from traverses across several of the great oceans. The method is simple, effective, and inexpensive; and the gatherings, if taken continuously, give a series of samples amounting to a section through the surface layer of the sea, a certain volume of water being pumped in continuously through the bottom of the ship, and strained through the fine silk nets, the mesh of which may be the three-hundredth of an inch across, before passing out into the sea again. In examining with a microscope such a series of gatherings across an ocean, two facts are brought prominently before the mind:

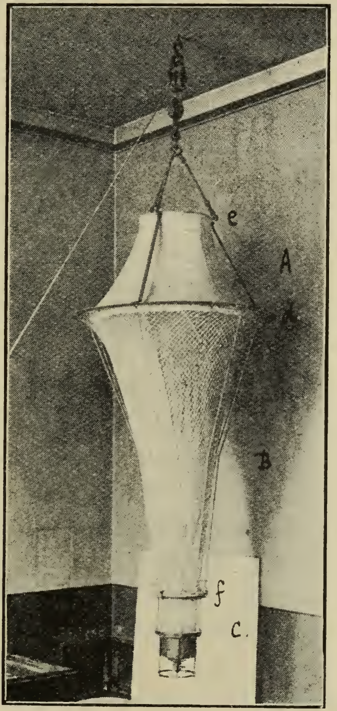

FIG. 6.—The Hensen Quantitative Net.

(1) The constant presence of a certain amount of minute living things;

(2) The very great variation in the quantity and in the nature of these organisms.

Such Plankton gatherings taken continuously from an ocean liner give, however, information only in regard to the *surface* fauna and flora of the sea—including many organisms of fundamental importance to man as the immediate or the ultimate food of fishes and whales and other useful animals.

It was therefore a great advance in Planktology when Professor Victor Hensen (1887) introduced his vertical, quantitative nets (fig. 6) which could be lowered down and drawn up through any required zones of the water. The highly original ideas and the ingenious methods of Hensen and his colleagues of the Kiel School of Planktology—whether all the conclusions which have been drawn from their results be accepted or not—have at the least inaugurated a new epoch in such oceanographic work; and have inspired a large number of disciples, critics and workers in most civilised countries, with the result that the distribution of minute organisms in the oceans and the fresh waters of the globe is now much more fully known than was the case twenty, or even ten, years ago. But perhaps the dominant feeling on the part of those engaged in this work is that, notwithstanding all this activity in research and the mass of published literature to which it has given rise, much still remains to be done, and that the Planktologist is still face to face with some of the most important unsolved problems of Biology.

The fundamental ideas of Hensen were that the Plankton, or assemblage of more or less minute drifting organisms (both animals and plants) in the sea, is uniformly distributed over an area where the physical conditions are approximately the same, and that by taking a comparatively small number of samples it would be possible to calculate the quantity of Plankton contained at the time of observation in a given sea area, and to trace the changes of this Plankton both in space and time. This was a sufficiently grand conception, and it has been of great service to science by stimulating many workers to further research. In order to obtain answers to the problems before him, Hensen devised nets of the finest silk of about 6,000 meshes in the square centimetre, to be hauled up from the bottom to the surface, and having their constants determined so that it was known what volume of water passed through the net under certain conditions. (See figure of the silk on Pl. IV., p. 36).

Now, if this constancy of distribution postulated by Hensen could be relied upon over considerable areas of the sea, far-reaching conclusions, having important bearings upon fisheries questions, might be arrived at; and such have, in fact, been put forward by the Kiel Planktologists and their followers, and have been quoted on many occasions.

Such generalisations are most attractive, and if it can be established that they are based upon sufficiently reliable data, their practical utility to man in connection with sea-fishery legislation will be very great. But the comparatively small number of the samples, and the observed irregularity in the distribution of the Plankton, such as the examples given for the Irish Sea in the last two of these Annual Reports, and over still wider areas such as the North Sea, leave the impression that further observations are required before such conclusions can be accepted as established.

Of the criticisms that have appeared in Germany, in the United States and elsewhere, the two most fundamental are: (1) that the samples are inadequate; and (2) that there is no such constancy and regularity in distribution as Hensen and some others have supposed.

It has been shown by Kofoid, by Lohmann, and by others that there are imperfections in the methods which were not at first realised, and that under some circumstances anything from 50 to 98 per cent. of the more minute organisms of the Plankton may escape capture by the finest silk quantitative nets. The mesh of the silk is 1-300th inch across, but many of the organisms are only 1-3000th inch in diameter, and so can readily escape.

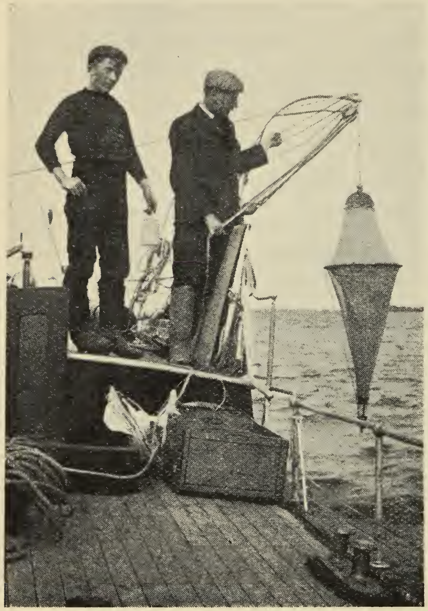

FIG. 7.—Closing Petersen-Hensen Net going down open.

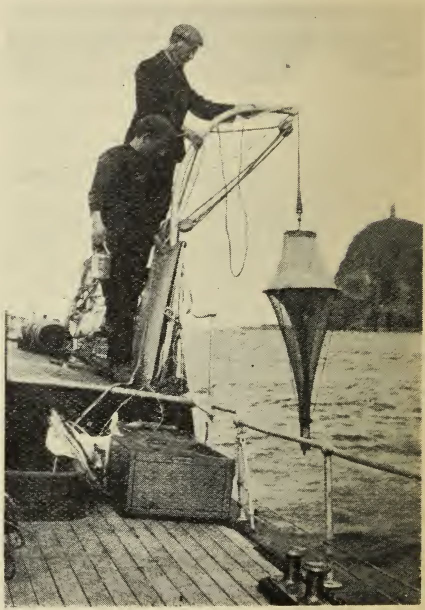

FIG. 8.—The same quantitative plankton net coming up closed.

Other methods have been devised to supplement the Hensen nets, such as the filtering of water pumped up through hose-pipes let down to known depths, and also the microscopic examination in the laboratory of the centrifuged contents of comparatively small samples of water obtained by means of closing water-bottles from various zones in the ocean. But even if deficiencies in the nets be thus made good by supplementary methods, and be allowed for in the calculations, there still remains the second and more fundamental source of error, namely, unequal distribution of the organisms in the water; and in regard to this a large amount of evidence has now been accumulated, since the time when Darwin, during the voyage of the "Beagle" on March 18, 1832, noticed off the coast of South America vast tracts of water discoloured by the minute floating Alga, *Trichodesmium erythræum*, which is said to have given its name to the Red Sea, and which Captain Cook's sailors in the previous century called "sea-sawdust." Many other naturalists since have seen the same phenomenon, caused both by this and by other organisms. It must be of common occurrence, and is widespread in the oceans, and it will be admitted that a quantitative net hauled vertically through such a Trichodesmium bank would give entirely different results from a haul taken, it might be, only a mile or two away, in water under, as far as can be determined, the same physical conditions, but free from Trichodesmium.

Nine nations bordering the North-West seas of Europe, some seven or eight years ago, engaged in a joint scheme of biological and hydrographical investigation, mainly in the North Sea, with the declared object of throwing light upon fundamental facts bearing on the economic problems of the fisheries. One important part of their programme was to test the quantity, distribution, and variation of the Plankton by means of periodic observations undertaken four times in the year (February, May, August and November) at certain fixed points in the sea. Many biologists considered that these periods were too few and the chosen stations too far apart to give reliable results. It is possible that even the original promoters of the scheme would now share that view, and the opinion has recently been published by the American Planktologist, Professor C. A. Kofoid—than whom no one is better entitled, from his own detailed and exact work, to express an authoritative verdict—that certain recent observations " can but reveal the futility of the Plankton programme of the International Commission for the investigation of the sea. The quarterly examinations of this programme will, doubtless, yield some facts of value, but they are truly inadequate to give any reliable view of the amount and course of Plankton production in the sea."*

It is evident that before we can base far-reach generalisations upon our Plankton samples, a minute study of the distribution of life in both marine and fresh waters at very frequent intervals throughout the year should be undertaken. Kofoid has made such a minute study of the lakes and streams of Illinois, and C. D. Marsh of those of Wisconsin; and similar intensive work is now being carried out at several localities in Europe.

Too little attention has been paid in the past to the distribution of many animals in swarms, some parts of the sea being crowded and neighbouring parts being destitute of such forms, and this not merely round coasts and in the narrow seas, but also in the open ocean. For example, some species of Copepoda and other small crustacea occur notably in dense crowds (fig. 11, Pl. I), and are not universally distributed. This is true also of some of the Diatoms, and also of larger organisms. Many naturalists have remarked upon the banks of Trichodesmium, of Medusæ and Siphonophora, of Salpæ, of Pteropods, of Peridinians and of other

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* "Internationale Revue der Hydrobiologie und Hydrographie," Vol. I., p. 846. December, 1908.

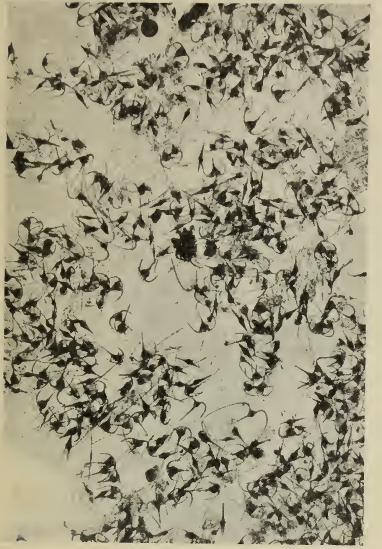


FIG. 9. Peridinian Plankton, consisting mainly of *Ceratium tripos*.

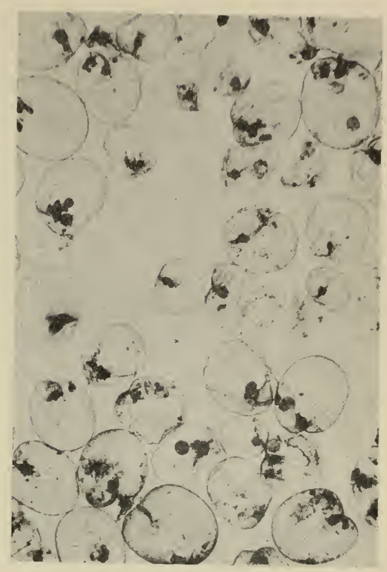


FIG. 10. Plankton, consisting almost wholly of *Noctiluca miliaris*.

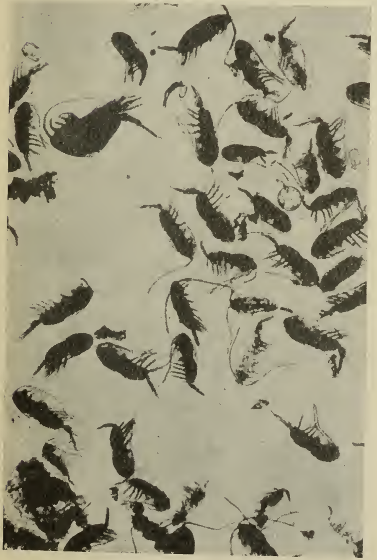


FIG. 11. Copepod Plankton, consisting mainly of *Acartia discaudata*. One *Temora* is seen.

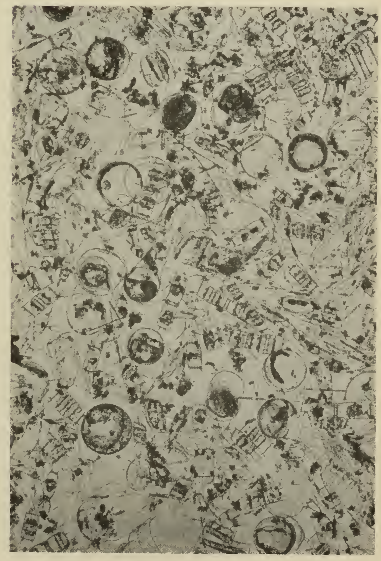
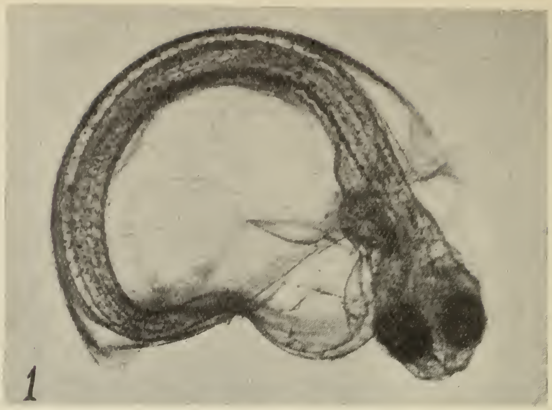


FIG. 12. Diatom Plankton consisting mainly of *Coscinodiscus* and *Biddulphia*.

Plate II.



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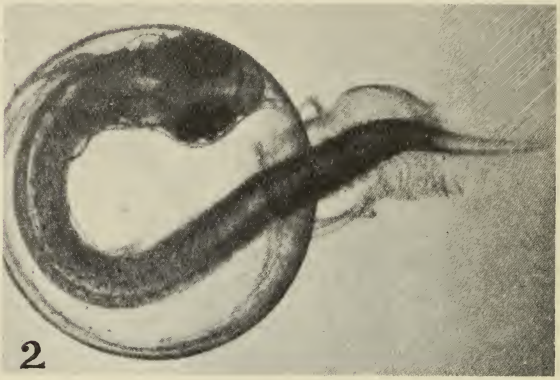

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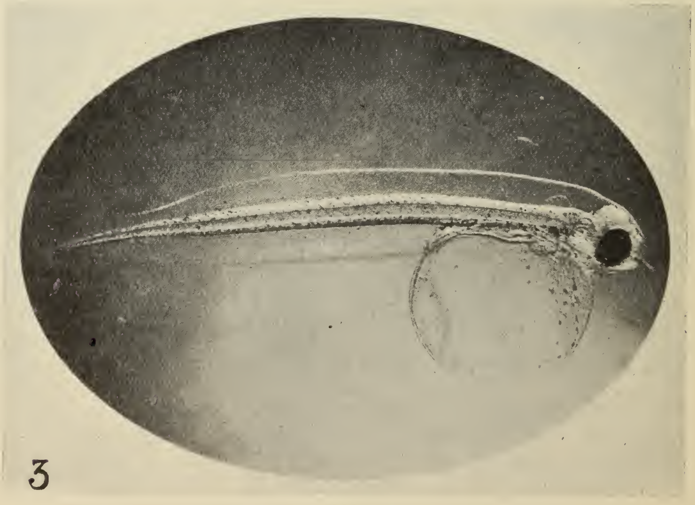

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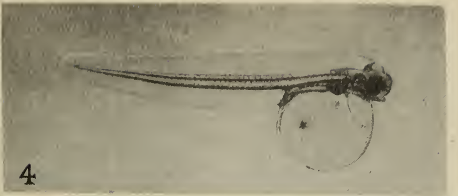

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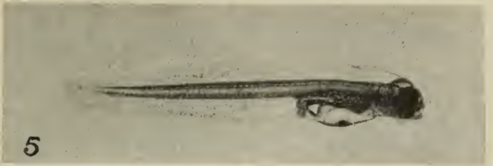

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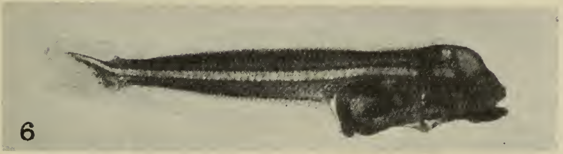

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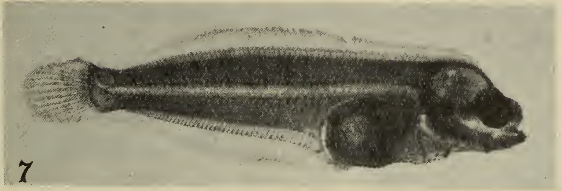

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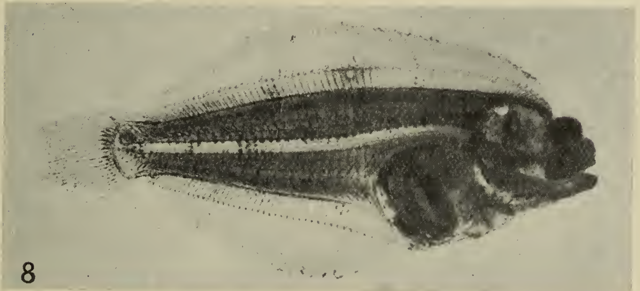

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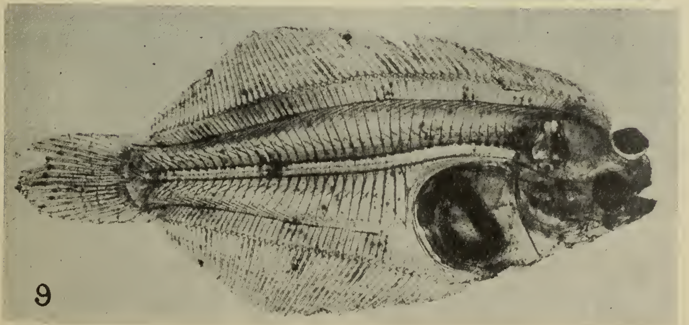

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Plate IV.

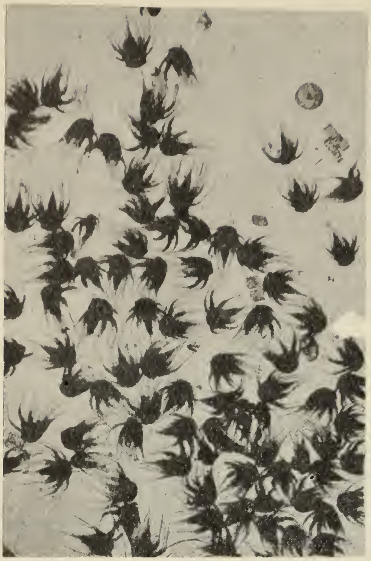

Fig. 18. Nauplius stage of *Balanus*.

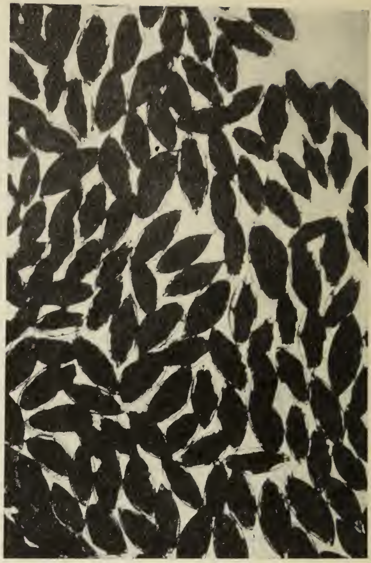

Fig. 19. Cypris stage of *Balanus*.

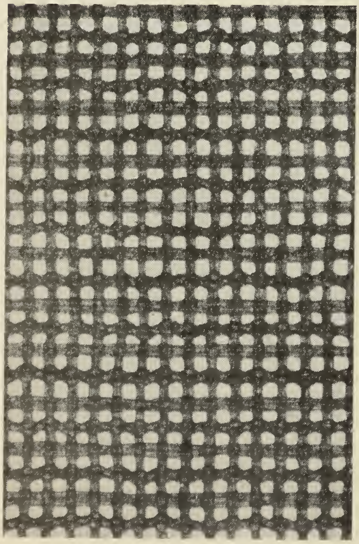

Fig. 20. Mesh of No. 20 silk when new. × 23

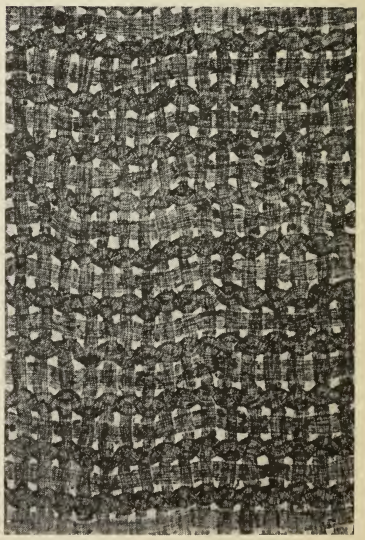

Fig. 21. Mesh of same silk after use in Nansen net for some months. × 23

common constituents of the Plankton. It is possible, however, that in some parts of the ocean, far from land, the Plankton may be distributed with the uniformity supposed by Hensen. It is important to recognise that at least three classes of locality exist in the sea in relation to distribution of Plankton:—

(1) There are estuaries and coastal waters where there are usually strong tidal and other local currents, with rapid changes of conditions, and where the Plankton is largely influenced by its proximity to land.

(2) There are considerable sea areas, such as the centre of the North Sea and the centre of the Irish Sea, where the Plankton is removed from coastal conditions, but is influenced by various factors which cause great irregularity in its distribution. These are the localities of the greatest economic importance to man, and to which attention should especially be directed.

(3) There are large oceanic areas in which there may be uniformity of conditions, but it ought to be recognised that such regions are not those in which the Plankton is of most importance to men. The great fisheries of the world, such as those of the North Sea, the cod fishery in Norway, and those on the Newfoundland Banks, are not in mid-ocean, but are in areas around the continents, where the Plankton is irregular in its distribution.

As an example of a locality of the second type, showing seasonal, horizontal and vertical differences in the distribution of the Plankton, we may take the centre of the Irish Sea, off the south end of the Isle of Man. Here, as in other localities which have been investigated, the Phyto-Plankton is found to increase greatly about the time of the vernal equinox, so as to cause a maximum, largely composed of Diatoms, at a period ranging from the end of March to some time in May. During this period the eggs of most of the edible fishes are hatched as larvæ. Figure 13 shows the curve formed by the catches of the total plankton in Port Erin Bay during 1908.

This Diatom maximum is followed by an increase in the Copepoda (minute crustacea), which lasts for a considerable time during the early summer; and as the fish larvæ and the Copepoda increase there is a rapid falling off in Diatoms. Less marked maxima of both Diatoms and Copepoda may occur again about the time of the autumnal equinox. These two groups—the Diatoms (fig. 12) and the Copepoda (fig. 11)—are the most important economic constituents in the Plankton. A few examples showing their importance to man may be given:—Man eats the oyster and the American clam, and these shell-fish feed upon Diatoms. Man feeds upon the cod, which in its turn may feed on the whiting, and that on the sprat, and the sprat on Copepoda, while the Copepoda feed upon Peridinians and Diatoms; or the cod may feed upon crabs, which in turn eat "worms," and these feed upon smaller forms which are nourished by the Diatoms. Or, again, man eats the

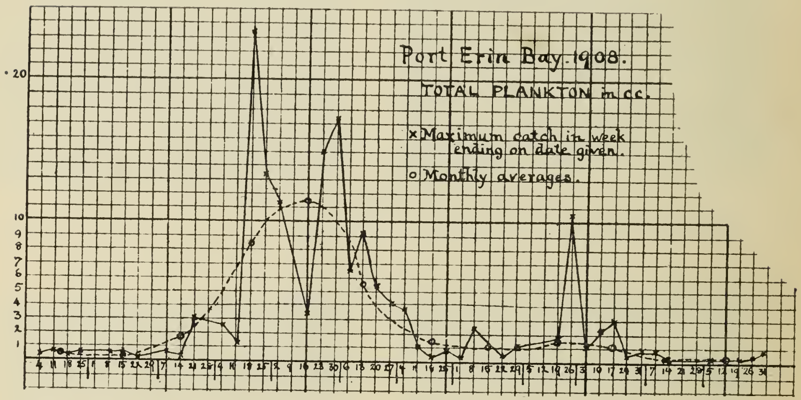

FIG. 13.

mackerel, which may feed upon young herring, and these upon Copepoda, and the Copepoda again upon Diatoms. All such chains of food matters from the sea seem to bring one through the Copepoda to the Diatoms, which may be regarded as the ultimate "producers" of food in the ocean. Thus the living food of man from the waters of the globe may be said to be the Diatoms and other microscopic organisms quite as much as the fishes.

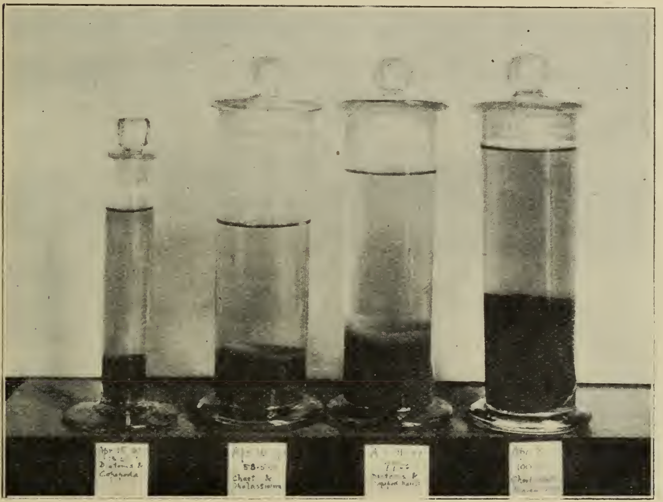

FIG. 14.—Four samples of plankton taken with the same net, in the same locality, between April 5th and 15th, 1907, and ranging from 13 c.c. to 100 c.c.

Two years ago, at the Leicester meeting of the British Association, I showed that if an intensive study of a small area be made, hauls being taken not once a quarter or once a month, but at the rate of ten or twelve a day, abundant evidence will be obtained as to: (1) variations in the distribution of the organisms, and (2) irregularities in the action of the nets. Great care is necessary in order to ensure that hauls intended for comparison are really comparable. Two years' additional work since in the same locality, off the south end of the Isle of Man, has only confirmed these results, viz., that the Plankton is liable to be very unequally distributed over the depths, the localities, and the dates. One net may encounter a swarm of organisms which a neighbouring net escapes, and a sample taken on one day may be very different in quantity from a sample taken under the same conditions next day. If an observer were to take quarterly, or even monthly, samples of the Plankton, he might obtain very different results according to the date of his visit. For example, on three successive weeks about the end of September he might find evidence for as many different far-reaching views as to the composition of the Plankton in that part of the Irish Sea. Consequently, hauls taken many miles apart and repeated only at intervals of months can scarcely give any sure foundation for calculations as to the population of wide sea areas.

These conclusions need not lead us to be discouraged as to the ultimate success of scientific methods in solving what may be called world-wide problems, but they suggest that it would be wise to secure by detailed local work a firm foundation upon which to build, and to ascertain more accurately the representative value of our samples before we base conclusions upon them.

I do not doubt that in limited, circumscribed areas of water, in the case of organisms that reproduce with great rapidity, the Plankton becomes more uniformly distributed, and a comparatively small number of samples may then be fairly representative of the whole. That is probably more or less the case with fresh-water lakes; and I have noticed it in Port Erin Bay in the case of Diatoms. In spring, and again in autumn, when suitable weather occurs, as it did two years ago at the end of September, the Diatoms may increase enormously, and in such circumstances they seem to be very evenly spread over all parts and to pervade the water to some depth; but that is emphatically not the case with the Copepoda and other constituents of the Plankton, and it was not the case even with the Diatoms during the succeeding year.

I have published in a former report an observation that showed very definite limitation of a large shoal of crab Zoëas, so that none were present in one net while in another adjacent haul they multiplied several times the bulk of the catch and introduced a new animal in enormous numbers. Had two expeditions taken samples that evening at what might well be considered as the same station, but a few hundred yards apart, they would have

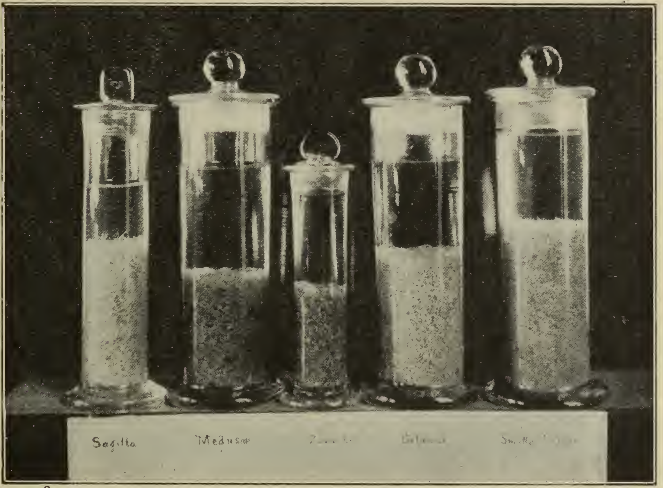

FIG. 15.—Series of plankton gatherings showing "swarms" of certain organisms (Haeckel's "Monotones Plankton").
The jars contain mainly Sagitta, Medusæ, Zoëa, Calanus, and smaller Copepoda, going from left to right.

arrived at very different conclusions as to the constitution of the Plankton in that part of the ocean.

It is possible to obtain a great deal of interesting information in regard to the "hylokinesis" (or changes of matter) of the sea without attempting a numerical accuracy which is not yet attainable. The details of measurement of catches and of computations of organisms become useless, and the exact figures are non-significant, if the hauls from which they are derived are not really comparable with one another and the samples obtained are not adequately representative of nature. If the stations are so far apart and the dates are so distant that the samples represent little more than themselves, if the observations are liable to be affected by any incidental factor which does not apply to the entire area, then the results may be so erroneous as to be useless, or worse than useless, since they may lead to deceptive conclusions. It is obvious that we must make an intensive study of small areas before we draw conclusions in regard to relatively large regions such as the North Sea or the Atlantic Ocean.

That, however, is not an argument against the legitimate use of quantitative methods, with limitations, and for certain purposes. It is necessary to know more than the fact that a certain species is present at a given locality at a certain time. We must endeavour to get some measure of its abundance, and that can only be done satisfactorily by counting individuals; at the same time recognising the imperfections of the methods and the approximate nature of the result, so that the numerical estimate will be regarded as relative rather than absolute. Our apparatus is not perfect enough, nor is the distribution of the organisms sufficiently uniform to enable us to calculate how many individuals of a Diatom, of a Copepod, or of a fish are present in the Irish Sea on a particular occasion; but we may aim at being able to make, with a reasonable approximation to the truth, such statements as: There are about ten times as many Diatoms in a special part of the Irish Sea now as there were last week, and in round numbers twice as many as at the corresponding period of last year.

With the object of formulating such views as to the nature of the Plankton at any particular time, and as to the changes, both diurnal and seasonal, and the determining factors of such changes, we must endeavour to make quantitative catches as accurately and as frequently as possible, so that our samples may be as nearly representative and as nearly comparable one with another as the difficult conditions will admit. These catches should be made with standard nets, should be preserved and measured according to a uniform system, and may then be compared in bulk; but, in addition, the more important

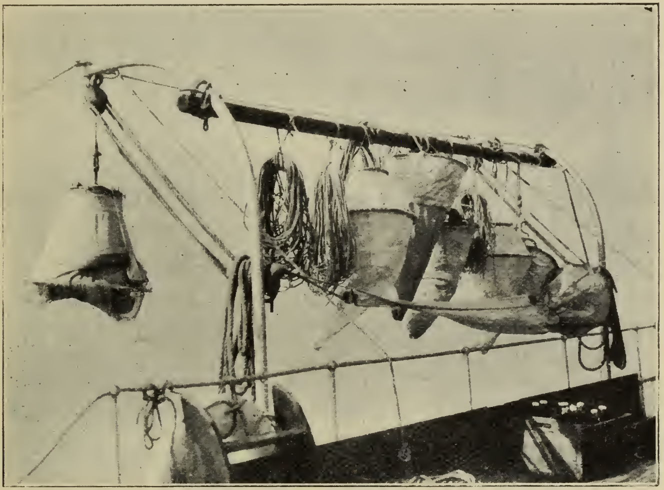

FIG. 16.—Plankton nets drying after an expedition on S.Y. "Ladybird" at Port Erin. (Photo by Edwin Thompson).

organisms should be counted approximately, and the results, in round numbers, may be used in comparing catches or in tracing changes; but such figures should not be made the basis of calculations as to the total numbers of such organisms in the oceans. In brief, the numerical results of quantitative work should be regarded as giving *relative* but not *absolute* information.

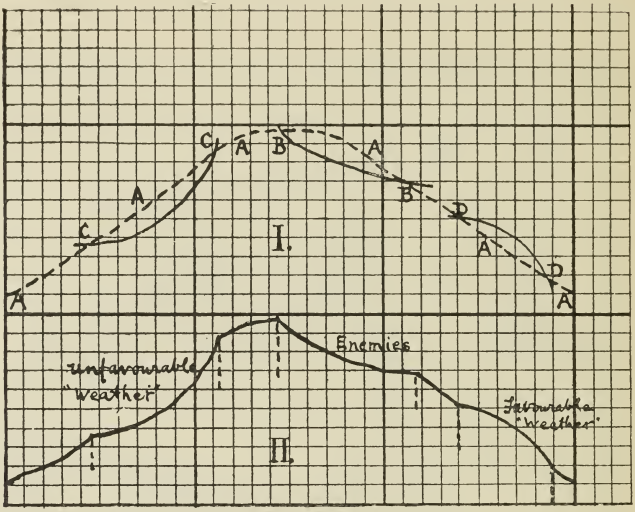

FIG. 17.—Diagram showing the influence of the factors C, B, D, upon the life-history A.

The factors causing the seasonal and other variations in the Plankton already pointed out may be grouped under three heads, as follows:

(1) The sequence of the stages in the normal life history of the different organisms.

(2) Irregularities introduced by the interactions of the different organisms.

(3) More or less periodic abnormalities in either time or abundance caused by the physical changes in the sea, which may be grouped together as "weather."

These are all obvious factors in the problem, and the constitution of the Plankton from time to time throughout the year must be due to their interaction. The difficulty is to disengage them from one another so as to determine the action of each separately (See fig. 17 which illustrates the effect of the above factors).

Figure 18, on Plate IV, shows the Nauplius stage of the common rock barnacle (*Balanus*). The adult is present in abundance on the rocks at Port Erin, and the Nauplii are sometimes found in enormous swarms in spring. Figure 19 shows the succeeding or " Cypris " stage, found in our tow-nets a little later and in much smaller quantities than the Nauplius—the reduced numbers in the later stage of the life-history being evidence of the action of enemies and other factors of the environment.

Amongst the physical conditions coming under the third heading, the temperature of the sea is usually given a very prominent place. I shall allude here to one aspect only of this matter.

It is often said that tropical and sub-tropical seas are relatively poor in Plankton, while the colder Polar regions are rich. In fishing Plankton continuously across the Atlantic it is easy from the collections alone to tell when the ship passes from the warmer Gulf Stream area into the colder Labrador current. This is the reverse of what we find on land, where luxuriant vegetation and abundance of animal life are characteristic of the tropics in contrast to the bare and comparatively lifeless condition of the Arctic regions. Brandt has made the ingenious suggestion that the explanation of this phenomenon is that the higher temperature in tropical seas favours the action of denitrifying bacteria, which therefore flourish to such an extent in tropical waters as seriously to diminish the supply of nitrogen food and so limit the production of Plankton. Loeb,[*] on the other hand, has recently revived the view of Murray, that the low temperature in Arctic waters so reduces the rate of all metabolic processes, and increases the length of life, that we have in the more abundant Plankton of the colder waters several generations living on side by side, whereas in the tropics with more rapid metabolism they would have died and disappeared. The temperature of the sea-water, however, appears to have little or no effect in determining the great vernal maximum of Phyto-Plankton.

Considering the facts of photosynthesis, there is much to be said in favour of the view that the development, and possibly also the larger movements, of the Plankton are influenced by the amount of sunlight, quite apart from any temperature effect.

Bullen[†] showed the correlation in 1903-07 between the mackerel catches in May and the amount of Copepod Plankton in the same sea. The food of these Copepoda has been shown by Dakin to be largely Phyto-Plankton; and Allen has lately[‡] correlated the average mackerel catch per boat in May with the hours of sunshine in the previous quarter of the year, thus establishing the following connection between the food of man and the weather:—Mackerel—Copepoda—Diatoms—Sunshine. One more example of the influence of light may be given. Kofoid has shown that the Plankton of the Illinois River has certain twenty-nine-day pulses, which are apparently related to the lunar phases, the Plankton maxima lagging about six days behind the times of full moon. The light from the sun is said to be 618,000 times as bright as that from the full moon; but the amount of solar energy derived from the moon is sufficient, we are told, appreciably to affect photosynthesis in the Phyto-Plankton. The effectiveness of the moon in this photosynthesis to that of the sun is said to be as two to nine, and, if that is so, Kofoid is probably justified in his contention that at the time of full moon the additional light available has a marked effect upon the development of the Phyto-Plankton.

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[*] *Darwin and Modern Science* (Cambridge, 1909), p. 247.

[†] M.B.A. Journ., viii. 269.

[‡] M.B.A. Journ., vii. 394.

As on land, so in the sea, all animals ultimately depend upon plants for their food. The plants are the producers and the animals the consumers in nature, and the pastures of the sea, as Sir John Murray pointed out long ago, are no less real and no less necessary than those of the land. Most of the fish which man uses as food spawn in the sea at such a time that the young fry are hatched when the spring Diatoms abound, and the Phyto-Plankton is followed in summer by the Zoo-Plankton (such as Copepoda), upon which the rather larger but still immature food fishes subsist. Consequently the cause of the great vernal maximum of Diatoms is one of the most practical of world problems, and many investigators have dealt with it in recent years. Murray first suggested that the meadows of the sea, like the meadows of the land, start to grow in spring simply as a result of the longer days and the notable increase in sunlight. Brandt has put forward the view that the quantity of Phyto-Plankton in a given layer of surface water is in direct relation to the quantity of nutritive matters dissolved in that layer. Thus the actual quantity present of the substance—carbon, nitrogen, silica, or whatever it may be—that is first used up determines the quantity of the Phyto-Plankton. Nathansohn in a recent paper* contends that what Brandt supposes never really happens; that the Phyto-Plankton never exhausts any food constituent, and that it develops just such a rate of reproduction as will compensate for the destruction to which it is subjected. This destruction he holds is due to two causes: currents carrying the Diatoms to unfavourable zones or localities, and the animals of the Plankton which feed on them. The quantity of Phyto-Plankton present in a sea will then depend upon the balancing of the two antagonistic processes—the reproduction of the Diatoms and their destruction. We require further knowledge in regard to their rate of reproduction and the amount of the destruction; but it has been calculated that one of these minute forms, less than the head of a pin, dividing into two at its normal rate of five times in the day, would at the end of a month form a mass of living matter a million times as big as the sun. The destruction that keeps such a rate of reproduction in check must be equally astonishing. It is claimed that the "Valdivia" results, and observations made since, show that the most abundant Plankton is where the surface water is mixed with deeper layers by rising currents. Nathansohn, while finding that the hour of the day has no effect on his results, considers that the development of the Phyto-Plankton corresponds closely with evidence of vertical circulation. Like some other workers, he emphasises the necessity of continuous intensive work in one locality. The "Challenger" and other great exploring expeditions forty years ago opened up problems of oceanography, but such work from vessels passing rapidly from place to place could not solve our present problems—the future lies with the naturalists at biological stations working continuously in the same locality the year round. As an example of the complexity of such problems, there seem to be two kinds of Diatom maxima found by

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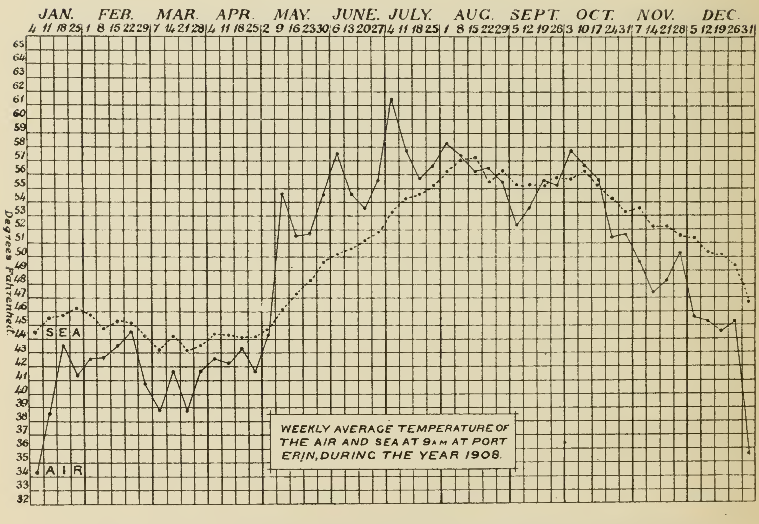
* "Monaco Bulletin," No. 140.

Nathansohn in the Mediterranean, one of *Chaetoceros* due to the afflux of water from the coast, and one of *Rhizosolenia calcar-avis*, due to a vertical circulation bringing up deeper layers of water.

The same principles and series of facts could be illustrated from the inland waters. Lakes periodically show Plankton maxima, which must be of vast importance in nourishing animals, and eventually the fishes used by man. Geologists have shown that Manitoba was in post-glacial times occupied by the vast lake Agassiz, with an estimated area of 110,000 square miles; and while the sediments of the extinct lake form now the celebrated wheat fields, supplying food to the nations, the shrunken remains of the water still yield, it is said, the greatest fresh-water fisheries in the world. It is to be hoped that nothing will be done further to reduce this valuable source of food. It is said that the Illinois fisheries yield at the rate of a pound a day throughout the year of cheap and desirable food to about 80,000 people—equivalent to one meal of fish a day for a quarter of a million people. The Canadian whitefish alone has yielded, I see, in recent years over 5,000,000 lbs. in a year, and all scientific men who have considered fishery questions will note with approval that all the fishing operations are now carried on under the regulations of the Dominion Government, and that fish hatcheries have been established on several of the great lakes which will, along with the necessary restrictions, form, it may be hoped, an effective safeguard against depletion. Much still remains to be done, however, in the way of detailed investigation and scientific exploitation. It has been shown in European seas that the mass of living food matters produced from the uncultivated water may equal that yielded by cultivated land. When aquiculture is as scientific as agriculture the regulated and cultivated waters of North America, both inland and marine, may prove to be more productive even than the great wheat lands of Manitoba.

Inland waters may be put to many uses; sometimes they are utilised as sewage outlets for great cities, sometimes they are converted into commercial highways, or they may become restricted because of the reclamation of fertile bottom lands. All these may be good and necessary developments, or any one of them may be obviously best under the circumstances, but due regard should always be paid to the importance and promise of natural waters as a perpetual source of cheap and healthful food to the people of the country.



The above curves show the result of the temperature observations taken at the Biological Station during 1908, the last complete year. They show very clearly how the temperature of the sea (dotted) lags behind that of the air (whole lines), being higher in winter and lower in the height of summer.

L.M.B.C. MEMOIRS.

During 1909 no less than three Memoirs have been issued:—No. XVII, PECTEN (the Scallop), by Mr. W. J. Dakin, M.Sc.; No. XVIII, ELEDONE (the local "Octopus"), by Miss A. Isgrove, M.Sc.; and No. XIX, on POLYCHAET LARVÆ (the young stages of the Higher Worms) at Port Erin, by Mr. F. H. Gravely, M.Sc. DORIS, the sea-lemon, by Sir Charles Eliot, and other Memoirs are also far advanced; and we hope to have a Memoir on our Irish Sea species of Ceratium and other Dinoflagellata from Prof. C. A. Kofoid, who did some work on our local material during his visit to our laboratory in 1908. This unusual amount of excellent material, which the Committee is happy to be able to issue to the scientific world, is, however, embarrassing from the point of view of expense. Lithographic plates, such as these Memoirs require, seem to become more costly, and with the growing elaboration of the subject more detailed illustration is necessary. The Committee are therefore always very grateful for special donations and grants which have in the past enabled the Treasurer to meet the expenses of plates for several of the above-mentioned Memoirs. Further donations to provide for the illustrations of those still unpublished will be very welcome.

The following shows a list of the Memoirs already published or arranged for:—

I. ASCIDIA, W. A. Herdman, 60 pp., 5 Pls.
II. CARDIUM, J. Johnstone, 92 pp., 7 Pls.
III. ECHINUS, H. C. Chadwick, 36 pp., 5 Pls.
IV. CODIUM, R. J. H. Gibson and H. Auld, 3 Pls.
V. ALCYONIUM, S. J. Hickson, 30 pp., 3 Pls.
VI. LEPEOPHTHEIRUS AND LERNÆA, A. Scott, 5 Pls.
VII. LINEUS, R. C. Punnett, 40 pp., 4 Pls.

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VIII. Plaice, F. J. Cole and J. Johnstone, 11 Pls.
IX. Chondrus, O. V. Darbishire, 50 pp., 7 Pls.
X. Patella, J. R. A. Davis and H. J. Fleure, 4 Pls.
XI. Arenicola, J. H. Ashworth, 126 pp., 8 Pls.
XII. Gammarus, M. Cussans, 55 pp., 4 Pls.
XIII. Anurida, A. D. Imms, 107 pp., 8 Pls.
XIV. Ligia, C. G. Hewitt, 45 pp., 4 Pls.
XV. Antedon, H. C. Chadwick, 55 pp., 7 Pls.
XVI. Cancer, J. Pearson, 217 pp., 13 Pls.
XVII. Pecten, W. J. Dakin, 144 pp., 9 Pls.
XVIII. Eledone, A. Isgrove, 113 pp., 10 Pls.
XIX. Polychaet Larvæ, F. H. Gravely, 79 pp., 4 Pls.
Doris, Sir Charles Eliot.
Cucumaria, E. Hindle.
Oyster, W. A. Herdman and J. T. Jenkins.
Ostracod (Cythere), Andrew Scott.
Buccinum, W. B. Randles.
Bugula, Laura R. Thornely.
Sagitta, E. J. W. Harvey.
Zostera, R. J. Harvey Gibson.
Himanthalia, F. J. Lewis.
Diatoms, F. E. Weiss.
Fucus, J. B. Farmer.
Botrylloides, W. A. Herdman.
Actinia, J. A. Clubb.
Hydroid, E. T. Browne.
Halichondria and Sycon, A. Dendy.
Sabellaria, A. T. Watson.

In addition to these, other Memoirs will be arranged for, on suitable types, such as *Pagurus*, *Pontobdella*, a Cestode and a Pycnogonid.

We append to this Report:—

(A) The usual Statement as to the constitution of the L.M.B.C., and the Laboratory Regulations;

(B) The Hon. Treasurer's Report, List of Subscribers, and Balance Sheet.

APPENDIX A.

THE LIVERPOOL MARINE BIOLOGY COMMITTEE (1909).

HIS EXCELLENCY THE RIGHT HON. LORD RAGLAN, Lieut.-Governor of the Isle of Man.

RT. HON. SIR JOHN BRUNNER, BART., M.P.

PROF. R. J. HARVEY GIBSON, M.A., F.L.S., Liverpool.

MR. W. J. HALLS, Liverpool.

PROF. W. A. HERDMAN, D.Sc., F.R.S., F.L.S., Liverpool, Chairman of the L.M.B.C., and Hon. Director of the Biological Station.

DR. W. E. HOYLE, M.A., Museum, Cardiff.

MR. P. M. C. KERMODE, Ramsey, Isle of Man.

The late MR. JOSEPH LOMAS, Liverpool.

SIR CHARLES PETRIE, Liverpool.

MR. E. THOMPSON, Liverpool, Hon. Treasurer.

MR. A. O. WALKER, F.L.S., J.P., formerly of Chester.

MR. ARNOLD T. WATSON, F.L.S., Sheffield.

Curator of the Station—MR. H. C. CHADWICK, A.L.S.

Assistant—MR. T. N. CREGEEN.

CONSTITUTION OF THE L.M.B.C.

(Established March, 1885.)

I.—The Object of the L.M.B.C. is to investigate the Marine Fauna and Flora (and any related subjects such as submarine geology and the physical condition of the water) of Liverpool Bay and the neighbouring parts of the Irish Sea and, if practicable, to establish and maintain a Biological Station on some convenient part of the coast.

II.—The Committee shall consist of not more than 12 and not less than 10 members, of whom 3 shall form a quorum; and a meeting shall be called at least once a year for the purpose of arranging the Annual Report, passing the Treasurer's accounts, and transacting any other necessary business.

III.—During the year the Affairs of the Committee shall be conducted by an Hon. Director, who shall be Chairman of the Committee, and an Hon. Treasurer, both of whom shall be appointed at the Annual Meeting, and shall be eligible for re-election.

IV.—Any Vacancies on the Committee, caused by death or resignation, shall be filled by the election at the Annual Meeting, of those who, by their work on the Marine Biology of the district, or by their sympathy with science, seem best fitted to help in advancing the work of the Committee.

V.—The Expenses of the investigations, of the publication of results, and of the maintenance of the Biological Station shall be defrayed by the Committee, who, for this purpose, shall ask for subscriptions or donations from the public, and for grants from scientific funds.

VI.—The Biological Station shall be used primarily for the Exploring work of the Committee, and the Specimens collected shall, so far as is necessary, be placed in the first instance at the disposal of the members of the Committee and other specialists who are reporting upon groups of organisms; work places in the Biological Station may, however, be rented by the week, month, or year to students and others, and duplicate specimens which, in the opinion of the Committee, can be spared may be sold to museums and laboratories.

LIVERPOOL MARINE BIOLOGICAL STATION
AT
PORT ERIN.

Laboratory Regulations.

I.—This Biological Station is under the control of the Liverpool Marine Biological Committee, the executive of which consists of the Hon. Director (Prof. Herdman, F.R.S.) and the Hon. Treasurer (Mr. E. Thompson).

II.—In the absence of the Director, and of all other members of the Committee, the Station is under the temporary control of the Resident Curator (Mr. H. C. Chadwick), who will keep the keys, and will decide, in the event of any difficulty, which places are to be occupied by workers, and how the tanks, boats, collecting apparatus, &c., are to be employed.

III.—The Resident Curator will be ready at all reasonable hours and within reasonable limits to give assistance to workers at the Station, and to do his best to supply them with material for their investigations.

IV.—Visitors will be admitted, on payment of a small specified charge, at fixed hours, to see the Aquarium and

Museum adjoining the Station. Occasional public lectures are given in the Institution by members of the Committee.

V.—Those who are entitled to work in the Station, when there is room, and after formal application to the Director, are:—(1) Annual Subscribers of one guinea or upwards to the funds (each guinea subscribed entitling to the use of a work place for three weeks), and (2) others who are not annual subscribers, but who pay the Treasurer 10s. per week for the accommodation and privileges. Institutions, such as Universities and Museums, may become subscribers in order that a work place may be at the disposal of their students or staff for a certain period annually; a subscription of two guineas will secure a work place for six weeks in the year, a subscription of five guineas for four months, and a subscription of £10 for the whole year.

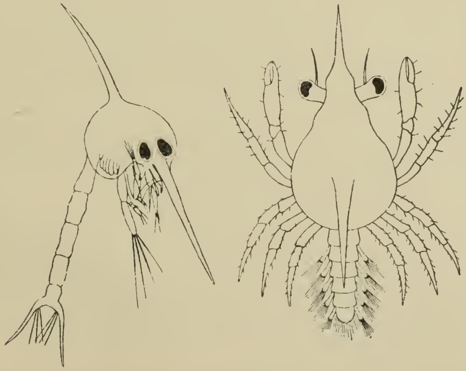
VI.—Each worker is entitled to a work place opposite a window in the Laboratory, and may make use of the microscopes and other apparatus, and of the boats, dredges, tow-nets, &c., so far as is compatible with the claims of other workers, and with the routine work of the Station.

VII.—Each worker will be allowed to use one pint of methylated spirit per week free. Any further amount required must be paid for. All dishes, jars, bottles, tubes, and other glass may be used freely, but must not be taken away from the Laboratory. Workers desirous of making, preserving, or taking away collections of marine animals and plants, can make special arrangements with the Director or Treasurer in regard to bottles and preservatives. Although workers in the Station are free to make their own collections at Port Erin, it must be clearly understood that (as in other Biological Stations) no specimens must be taken for such purposes from the

Laboratory stock, nor from the Aquarium tanks, nor from the steam-boat dredging expeditions, as these specimens are the property of the Committee. The specimens in the Laboratory stock are preserved for sale, the animals in the tanks are for the instruction of visitors to the Aquarium, and as all the expenses of steam-boat dredging expeditions are defrayed by the Committee, the specimens obtained on these occasions must be retained by the Committee (*a*) for the use of the specialists working at the Fauna of Liverpool Bay, (*b*) to replenish the tanks, and (*c*) to add to the stock of duplicate animals for sale from the Laboratory.

VIII.—Each worker at the Station is expected to lay a paper on some of his results—or at least a short report upon his work—before the Biological Society of Liverpool during the current or the following session.

IX.—All subscriptions, payments, and other communications relating to finance, should be sent to the Hon. Treasurer. Applications for permission to work at the Station, or for specimens, or any communications in regard to the scientific work should be made to Professor Herdman, F.R.S., University, Liverpool.



Young Crabs (Zoëa and Megalopa stages)—enlarged.

Appendix B.

HON. TREASURER'S STATEMENT.

As usual the financial statement for the year is shown in the few following pages.

Three new L.M.B.C. Memoirs have been published during the year, namely, Pecten (the common scallop), Eledone (an octoped cuttle fish) and Polychaet Larvæ. The two former are illustrated with finely lithographed plates, and the cost of producing them is necessarily great. Nineteen Memoirs have already been issued and there are more in course of preparation. Doris by Sir Charles Eliot is already far advanced, and it is hoped that Zostera, Sagitta, Buccinum and the Oyster will follow soon.

Unless more funds are forthcoming the publication of these Memoirs will have to be delayed, and the Treasurer hopes that further donations will be received to meet their cost. The Aquarium at Port Erin continues to prove a source of great interest to visitors to the Isle of Man, but owing to the bad season it is to be regretted that the present receipts do not quite equal those of last year.

The expenses of the Biological Station annually grow heavier, the work done there being continually on the increase as is shown in this Report. More subscribers are badly needed, and the Treasurer hopes that those interested in the work carried on by the L.M.B.C. will do what they can to help to increase the list.

Edwin Thompson,
Hon. Treasurer.

1, Croxteth Grove,
Liverpool.
December, 1909.

SUBSCRIBERS.

	£	s.	d.
Beaumont, W. I., Citadel Hill, Plymouth ...	1	1	0
Briscoe, F. W., Colby, Isle of Man	0	10	6
Brown, Prof. J. Campbell, University, Liverpool..	1	1	0
Browne, Edward T., B.A., 141, Uxbridge-road, Shepherd's Bush, London	1	1	0
Boyce, Sir Rubert, F.R.S., University, Liverpool	1	1	0
Brunner, Mond & Co., Northwich...	1	1	0
Brunner, Sir John, Bart., M.P., Silverlands, Chertsey	5	0	0
Brunner, J. F. L., M.P. 23, Weatherley Gardens, London, S.W.	2	2	0
Bullen, Rev. R. Ashington, Heathside-road, Woking	1	1	0
Caton, Dr., 78, Rodney-street, Liverpool	1	1	0
Clubb, J. A., Dr., Public Museums, Liverpool ...	0	10	6
Crellin, John C., J.P., Andreas, I. of Man... ...	0	10	6
Crosfield, Harold G., Fulwood-park, Liverpool ...	1	1	0
Dale, Vice-Chancellor, University, Liverpool ...	1	1	0
Dixon-Nuttall, F. R., J.P., F.R.M.S., Prescot ...	2	2	0
Eliot, Sir Charles, University, Sheffield	1	1	0
Ellis, R. Williams, Chwilog, N. Wales	1	1	0
Gaskell, Holbrook, J.P., the late, Woolton Wood...	1	1	0
Halls, W. J., 35, Lord-street, Liverpool	1	1	0
Headley, F. W., Haileybury College, Hertford ...	1	1	0
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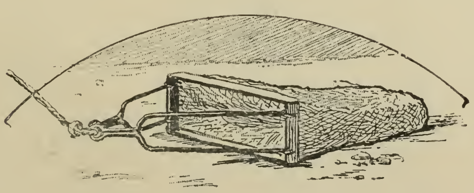

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